generating radicals at a pressure of more than 100 mTorr into a plasma in advance and for supplying a required amount of the radicals to said vacuum processing chamber;

said plasma generating means for supplying a second gas which contains at least different molecules than the first gas for generating ions to said vacuum processing chamber and generating a plasma in said vacuum processing chamber at a pressure of 50 mTorr or less;

a pulse bias applying means connected to said sample table and for applying a pulse bias voltage to said sample table; and

a voltage suppressing means for suppressing a voltage rising generated by applying said pulse bias voltage corresponding to an electrostatic attracting capacity of said electrostatic attracting means.

In the Abstract:

Please replace the original abstract with the abstract provided on a separate sheet herewith.

REMARKS

Reconsideration and allowance of this application, as amended, is respectfully requested.

This amendment is in response to the Office Action dated October 3, 2002. By the present amendment, the claims have been amended for clarification of the invention, and the abstract has been amended to be more clearly reflective of the presently claimed invention.

Briefly, the present invention is directed to improve the ability to form fine patterns in a plasma processing apparatus while, at the same time, increasing the speed of the plasma processing operation (e.g., see page 1, line 11 et seq.). To accomplish this, it is desirable to decrease the pressure of the processing gas while increasing the plasma density. However, as discussed on page 2, line 1 et seq., a problem which exists in such operations is that, when etching oxides with fluorocarbons, it is difficult to increase the selectivity of the oxide material because of excessive dissociation of the processing gas. Pages 2-10 describe various prior art techniques to try to overcome this problem. The present invention is directed particularly to obtaining a large size uniform plasma without excessive dissociation, as discussed on page 10, line 12 et seq.

In accordance with one feature defined in the present divisional application, a pulse bias source is provided, such as shown by the numeral 17 in the Fig. 1 embodiment to operate in conjunction with a high frequency source. A second aspect of the claimed invention is the use of a radical supply arrangement for decomposing a first gas to generate radicals to provide in advance to the vacuum chamber, and a plasma generating mean for supplying a second gas different than the first gas to provide to the vacuum chamber.

Referring to Fig. 1, the first aspect of the present claims can be appreciated from the discussion beginning on page 31 concerning the pulse bias source 17. As can be seen in Fig. 1, the plasma processing apparatus includes a high frequency electrical power source such as 16 operating in conjunction with a pulse bias source 17. As discussed on page 32, line 17 et seq. the pulse bias source serves to help control the etching. As noted on page 33, line 16 et seq., this control can include controlling ion energy. The combination of the high-frequency power source and the

pulse bias source serves to permit the formation of an extremely fine pattern at a high processing speed.

Page 77 through 79 discuss the second feature of the present invention (defined, for example, in claims 23-27) of a radical supplying means for decomposing or forming a first gas for generating radicals in advance and supplying these radicals to the vacuum processing chamber in conjunction with supplying a second gas which contains different molecules than the first gas to generate ions in the vacuum processing chamber. As discussed on pages 77-79, this serves to permit improved etching.

Reconsideration and allowance of claims 14-16 over Arai (USP 6,110,287) and claims 17 and 18 over the combination of Arai in view of Ogasawara (USP 5,997,962) is respectfully requested. All of these claims include the feature of the pulse bias supplying means operating in conjunction with the high frequency electric power source, as discussed above. It is respectfully submitted that Arai fails to teach or suggest this combination of a pulse bias applying means with a high frequency electrical power, particularly in conjunction with the overall combination of features set forth in claims 14-18. Arai discusses using a high frequency power modulated by a low frequency for plasma generation (e.g., see column 4, lines 5-27, as well as Fig. 1). The further description is provided in Arai with regard to a high frequency wave (for example, 13.56 MHz) applied to a lower electrode without modulation (e.g., see column 13, lines 10-19 as well as column 18, lines 3-12 in conjunction with Fig. 18). Although this may be of general interest, it is respectfully submitted that this is <u>not</u> a pulse bias source for applying a pulse bias to the sample being held by electrostatic means on a sample table. As such, it is respectfully submitted that Arai fails to teach or suggest the claimed structural combination set forth in each of claims 14-18. With

regard to this, it is noted that Ogasawara fails to add anything to Arai to make up for the shortcoming.

In addition, it is noted that claims 16 and 18 include the further limitation of a voltage suppressing means operating in conjunction with the pulse bias voltage. As set forth in claim 16, the voltage suppressing means is designed:

> "so that voltage change due to an electrostatic attracting film of said electrostatic attracting means during one cycle of pulse is suppressed to one-half of said pulse bias voltage."

A similar limitation is found in claim 18. It is respectfully submitted that Arai completely fails to teach or suggest any such voltage suppression means for suppressing voltage change due to an electrostatic attracting film of the electrostatic attracting means in conjunction with the operation of the pulse bias source.

Accordingly, in light of the shortcomings of Arai in meeting the features defined in claims 14-18, reconsideration and allowance of these claims over Arai is respectfully requested. Further consideration of claims 17 and 18 over the combination of Arai and Ogasawara is also respectfully requested inasmuch as Ogasawara fails to teach or suggest anything which would lead one to modify Arai to provide the above-discussed structure or operational advantages.

Reconsideration and allowance of claims 23-27 over the combination of Kadomura (USP 5,567,268) and Kofuji (USP 6,231,777) is also respectfully requested. By the present amendment, each of claims 23-27 has been amended to clearly define that the radical supplying means decomposes a first gas to generate radicals at a pressure of more than 100 mTorr in advance and supplying these radicals to the vacuuming processing chamber. In addition, the claims now define a means for supplying a second gas containing at least different molecules than the first gas to generate ions to the vacuum processing chamber. The claims also define

that the plasma generating means generates plasma at a pressure of 50 mTorr or less. It is respectfully submitted that the Kadomura reference fails to teach or suggest this combination of first and second gases, different from one another, in conjunction with the pressures now defined in the claims. Kadomura also fails to teach or suggest the overall combination of such gases in conjunction with the electrostatic attracting means. Nothing in Kofuji would suggest the substantial modification of Kadomura which would be necessary to arrive at the features defined in claims 23-27. Accordingly, reconsideration and allowance of these claims over the combination of Kadomura and Kofuji is respectfully requested.

Finally, reconsideration and removal of the objection to claim 18 as being an improper multidependent claim is also respectfully requested. Claim 18 has now been amended to depend solely from claim 17, noting, as the Examiner did, that the features defined in claim 18 are already substantially contained in claim 16. Accordingly, reconsideration and removal of the objection to claim 18 is respectfully requested.

Attached hereto is a marked-up version of the changes made to the claims by the current amendment. The attached page is captioned "Version with markings to show changes made."

If the Examiner believes that there are any other points which may be clarified or otherwise disposed of, either by telephone discussion or by personal interview, the Examiner is invited to contact applicants' undersigned attorney at the number indicated below.

To the extent necessary, the applicants petition for an extension of time under 37 CFR 1.136. Please charge any shortage in the fees due in connection with the

filing of this paper, including extension of time fees, to the deposit account of Antonelli, Terry, Stout & Kraus, Deposit Account No. 01-2135 (520.35237VX3).

Respectfully submitted,

ANTONELLI, TERRY, STOUT & KRAUS, LLP

By _____
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GEM/kd
703/312-6600

VERSION WITH MARKINGS TO SHOW CHANGES MADE

In the claims:

Claims 17, 18, 23, 24, 25, 26 and 27 have been amended as follows:

17. (Amended) A plasma processing apparatus comprising:

a pair of electrodes opposite to each other having a gap between the electrodes of [10] 30 mm to [50] 100 mm;

an electrostatic attracting means for holding a sample onto one of said electrodes by [a] an electrostatic attracting force;

a gas introducing means for introducing an etching gas into an environment holding said sample;

an evacuating means for evacuating and [deperssurizing] depressurizing said environment to a pressure condition of 0.5 Pa to 4.0 Pa;

a plasma generating means for forming said etching gas into a plasma under said pressure condition by a high frequency electric power of 10 MHz to 500 MHz; and

a pulse bias applying means for applying a pulse bias voltage to said one of said [electrode] electrodes mounting said sample;

thus an insulator film in said sample being plasma processed.

18. (Amended) A plasma processing apparatus according to [any one of claims] claim [16 and] 17, which further comprises:

a voltage suppressing means for suppressing a voltage rising generated by applying said pulse bias voltage corresponding to an electrostatic attracting capacity of said electrostatic attracting means;

said voltage suppressing means setting a period of said pulse bias voltage so that voltage change due to an electrostatic attracting film of said electrostatic attracting means during one cycle of pulse is suppressed to one-half of said pulse bias voltage.

23. (Amended) A plasma processing apparatus comprising a vacuum processing chamber, a sample table for mounting a sample to be processed in said vacuum processing chamber, and a plasma generating means, which further comprises:

an electrostatic attracting means for holding said sample onto said sample table by electrostatic attracting force;

a bias applying means for applying a bias voltage to said sample;

a radical supplying means having a means decomposing a first gas for generating radicals at a pressure of more than 100 mTorr in advance and for supplying a required amount of the radicals to said vacuum processing chamber;

a means for supplying a second gas which contains at least different molecules than the first gas for generating ions to said vacuum processing chamber; and

a plasma generating means for generating a plasma in said vacuum processing chamber at a pressure of 50 mTorr or less;

wherein SiO2 is [being] used as said sample.

24. (Amended) A plasma processing apparatus comprising a vacuum processing chamber, a sample table for mounting a sample to be processed in said vacuum processing chamber, and a plasma generating means, which further

comprises:

an electrostatic attracting means for holding said sample onto said sample table by an electrostatic attracting force;

a pulse bias applying means for applying a pulse bias voltage to said sample;

a radical generating plasma supplying means for forming a first gas for generating radicals at a pressure of more than 100 mTorr into a plasma in advance and for supplying a required amount of the radicals to said vacuum processing chamber; and

said plasma generating means for supplying a second gas which contains at least different molecules than the first gas for generating ions to said vacuum processing chamber and for generating a plasma in said vacuum processing chamber at a pressure of 50 mTorr or less;

wherein SiO_2 [being] is used as said sample.

25. (Amended) A plasma processing apparatus comprising a vacuum processing chamber, a sample table for mounting a sample to be processed in said vacuum processing chamber, and a plasma generating means including a high frequency electric power source, which further comprises:

an electrostatic attracting means for holding said sample onto said sample table by an electrostatic attracting force;

a pulse bias applying means for applying a pulse bias voltage to said sample;

a radical generating plasma supplying means for forming a first gas for generating radicals at a pressure of more than 100 mTorr into a plasma in advance and for supplying a required amount of the radicals to said vacuum processing chamber; and

said plasma generating means for supplying a second gas which contains at least different molecules than the first gas for generating ions to said vacuum processing chamber and for generating a plasma in said vacuum processing chamber at a pressure of 50 mTorr or less;

wherein said high frequency electric power source [applying] applies a high frequency voltage of 10 MHz to 500 MHz, said vacuum processing chamber being depressurized to 0.5 to 0.4 pa.

26. (Amended) A plasma processing apparatus comprising a vacuum processing chamber, a sample table for mounting a sample to be processed in said vacuum processing chamber, and a plasma generating means, which further comprises:

an electrostatic attracting means for holding said sample onto said sample table by an electrostatic attracting force;

a radical generating plasma supplying means for forming a first gas for generating radicals at a pressure of more than 100 mTorr into a plasma in advance and for supplying a required amount of the radicals to said vacuum processing chamber;

said plasma generating means for supplying a second gas which contains at least different molecules than the first gas for generating ions to said vacuum processing chamber and generating a plasma in said vacuum processing chamber at a pressure of 50 mTorr or less;

a pulse bias applying means connected to said sample table and for applying a pulse bias voltage to said sample table; and

a voltage suppressing means for suppressing a voltage rising generated by

applying said pulse bias voltage corresponding to an electrostatic attracting capacity of said electrostatic attracting means.

27. (Amended) A plasma processing apparatus comprising a vacuum processing chamber, a sample table for mounting a sample to be processed in said vacuum processing chamber, and a plasma generating means, which further comprises:

an electrostatic attracting means for holding said sample onto said sample table by an electrostatic attracting force;

a radical generating plasma supplying means for forming a first gas for generating radicals at a pressure of more than 100 mTorr into a plasma in advance and for supplying a required amount of the radicals to said vacuum processing chamber;

said plasma generating means for supplying a second gas which contains at least different molecules than the first gas for generating ions to said vacuum processing chamber and generating a plasma in said vacuum processing chamber at a pressure of 50 mTorr or less;

a pulse bias applying means connected to said sample table and for applying a pulse bias voltage to said sample table; and

a voltage suppressing means for suppressing a voltage rising generated by applying said pulse bias voltage corresponding to an electrostatic attracting capacity of said electrostatic attracting means.

ABSTRACT

A plasma processing apparatus is provided which includes a vacuum processing chamber, a sample table to hold a sample by electrostatic attraction and a plasma generating arrangement using a high frequency source. In addition, a pulse bias source is provided to control etching of the sample. Alternatively, or in combination with the pulse bias source, a radical supply arrangement can be used to decompose or form a first gas by generating radicals in advance and supplying the radicals to the vacuum processing chamber, in conjunction with supplying a second gas, containing different molecules than the first gas, to the vacuum chamber. A plasma is then generated in the vacuum chamber. By use of this arrangement, a fine pattern can be formed with increased processing speed.